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RESEARCH PAPER

Spin coating of hydrophilic polymeric films for enhanced centrifugal flow control by serial siphoning

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Abstract In this paper, we implement rotational flow control on a polymeric microfluidic "lab-on-a-disc" platform by combining serial siphoning and capillary valving for sequential release of a set of on-board stored liquid reagents into a common (assay) channel. The functionality of this integrated, multi-step, multi-reagent centrifugal assay platform critically depends on the capability to establish very reproducible, capillary-driven priming of the innately only weakly hydrophilic siphon microchannels made from common poly(methyl methacrylate) (PMMA) substrates. Due to the relatively high contact angle of the native PMMA substrate, it was practically impossible to ensure sequential release of on-board stored reagents using the capillary-driven serial siphon valves. In this work, we demonstrate that spin-coated hydrophilic films of poly(-vinyl alcohol) (PVA) and (hydroxypropyl)methyl cellulose (HPMC) provide stable contact angles on PMMA substrates for more than 60 days. The deposited films were characterized using contact angle measurements, surface energy calculations and X-ray photoelectron spectroscopy spectra. The PVA and HPMC films reduced the water contact angle of the PMMA substrate from 68° to 22° and 27° while increasing their surface energies from 47 to 62 and 57 mN m^{-1}, respectively. On the centrifugal microfluidic platform, the films were validated to enable the effective and reproducible priming of the serial siphon microchannels at low rotational frequencies while ensuring that the in-line capillary valves are not opened until their respective burst frequencies are passed. Furthermore, the biocompatibility of the proposed surface modification method was examined, and the platform was used to run a sandwich immunoassay for the detection of human immunoglobulin G, and its performance was proven to be comparable to dynamic coating using surfactants.

Keywords Hydrophilic polymers · Spin coating · Centrifugal microfluidic platform · Lab-on-a-disc · Serial siphoning · Capillary valving

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1 Introduction

One of the most crucial steps in biological analysis systems is the spatiotemporally controllable release of a repertoire of assay reagents. Siphon microchannels comprise attractive structures in centrifugal platforms as they can be utilized for several functions, such as valving, pumping, metering and mixing (Ducrée et al. 2007). Moreover, centrifugal forces have been shown to positively benefit active flow-through assays, especially for surface-based assays, by decreasing total assay time and increasing assay sensitivity (Peytavi et al. 2005).

On the here considered centrifugal microfluidic "lab-on-a-disc" platform, we chose serial siphoning to direct the sequential release of bioreagents (Steigert et al. 2007). Yet, the requirement of long-term hydrophilic microchannel surfaces represents major challenge of serial siphoning (Siegrist et al. 2009). A plethora of surface modification

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